Evaluation of synthetic CTs generated from CBCTs and need for plan adaptation in offline adaptive lung radiation therapy

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Purpose/Objective:

Offline adaptive radiotherapy (ART) is resource intensive and therefore it is crucial to identify if adaptation is beneficial for a patient beforehand. The software AdaptBox (ART-PlanTM, TheraPanacea) combines an AI-based generation of synthetic CTs (sCT) from Cone-Beam-CTs (CBCT), automatic segmentation and a dose calculation based on the primary radiation treatment plan (RTP). This study evaluated AdaptBox in the context of offline ART for patients with NSCLC stage III.

Material/Methods:

CBCTs of 9 NSCLC stage III patients who received standard chemoradiotherapy in 30–33 treatment fractions and a total prescribed dose of 60-66 Gy were included. Every 5th fraction was analyzed (N= 68 sCTs). The mean HU–values of tumor and OAR in the sCTs have been compared to the respective planning CTs (PLCT). A visual evaluation of the sCTs has been performed, assessing image quality, segmentation accuracy, and target volume propagation. Calculated DVHs were visually compared for the analyzed fractions. The monitoring of pre-defined DVH-constraints offered by AdaptBox was not used in this analysis.

Results:

OARs contouring was overall performed well. The Image quality of sCTs has significantly improved compared to CBCTs; however streaking artifacts were still visible. The lung-liver boundary was incorrectly detected for some fractions, impeding the definition of the total lung volume. Most likely caused by free-breathing CBCT acquisition. Mean HU–values for target, left lung and heart are presented in fig. 1. For the lungs the mean HU–values in the sCT tend to be lower, with mean error left lung -28,99 HU [-109.52 - 25.14 HU] and right lung -26,63 HU [-101,096 - 34,70 HU]. For the CTV the mean error was -111.08 HU [-260.14 - 40,68 HU]. For the heart the mean HU-values in the sCT are exclusively lower, with mean -44.43 HU [-110.06 - -0.48 HU]. The DVH comparison is representatively shown for one patient in fig. 2.

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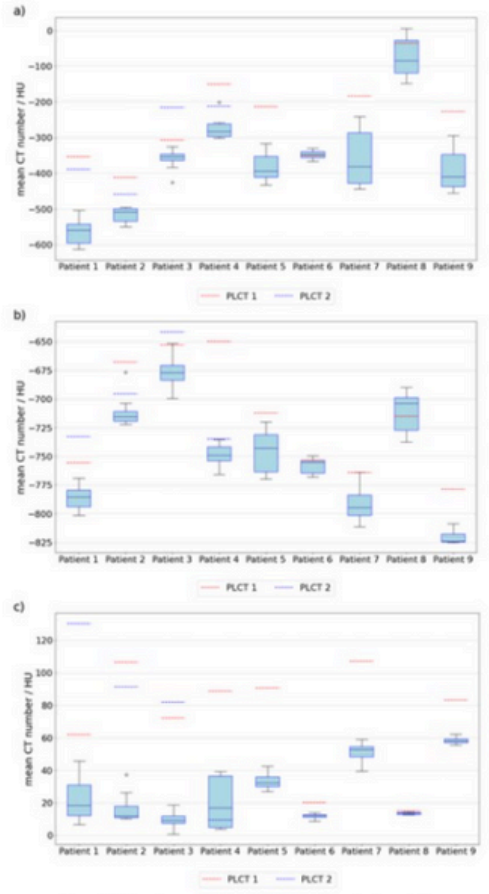

Fig 1: HU-values obtained from the sCTs of the evaluated fractions for a) CTV, b) the left lung, and c) the heart, compared to the HU-values of PLCTs.

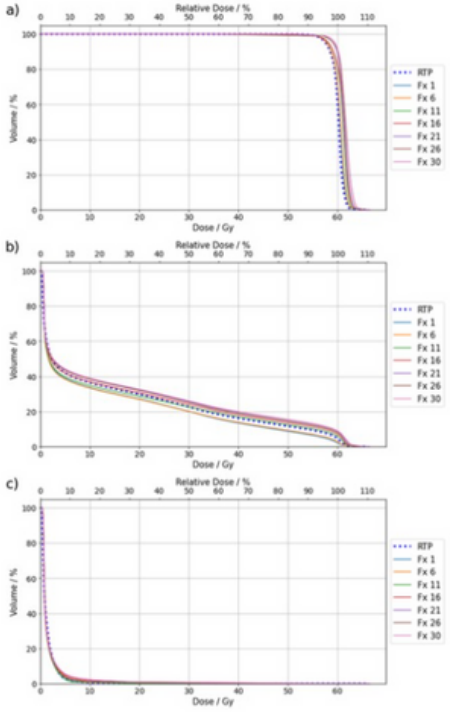

Fig 2: Dose-volume histograms calculated for RTP and fractions 1,6,11,16,21,26 and 30 for: a) PTV, b) left lung c) heart, exemplary for patient 8 .

Conclusion:

Image quality, HU accuracy and segmentation seem adequate to monitor dose deposition on daily CBCT imaging. When defining dose-constraints which could trigger plan adaptation, the uncertainties related to acquisition of CBCT should be considered, e.g. lung V20%. This DVH-constraints will be defined in a consecutive project. Overall, this study supports the use of AdaptBox to determine the need for plan adaptation for stage III NSCLC patients through the observation of the fractional calculated dose.

Keywords: syntheticCT, lung cancer